

Solid Oxide Fuel Cell Technology for Hybrid Power Generation

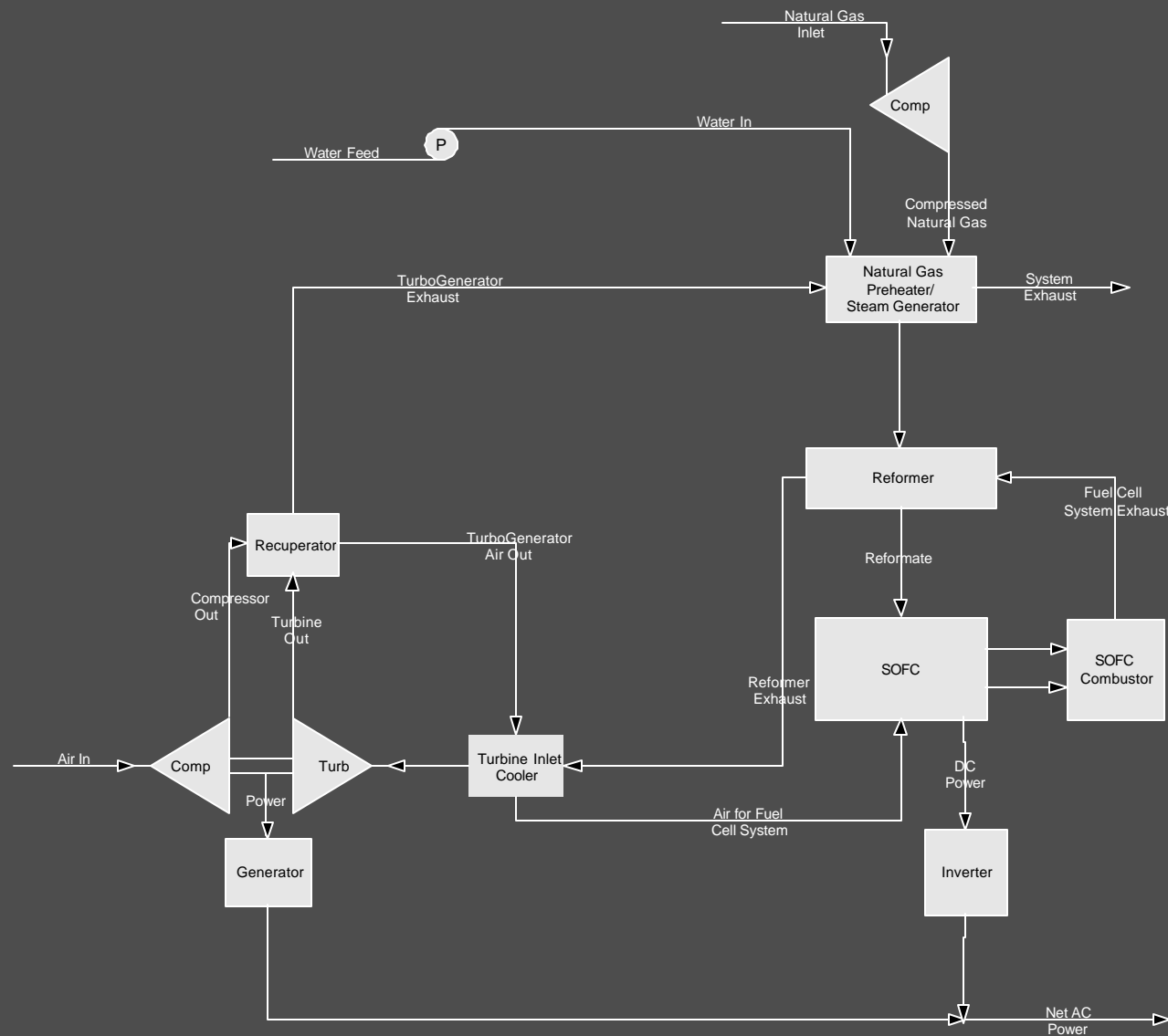
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**GE Hybrid Power
Generation Systems**





SOFC Hybrid System Concept







Key System Components

- SOFC
 - High-performance reduced-temperature planar cells
- Microturbine
 - Commercial systems
- Other subsystems
 - Fuel processor
 - Thermal management
 - Flexible control subsystem



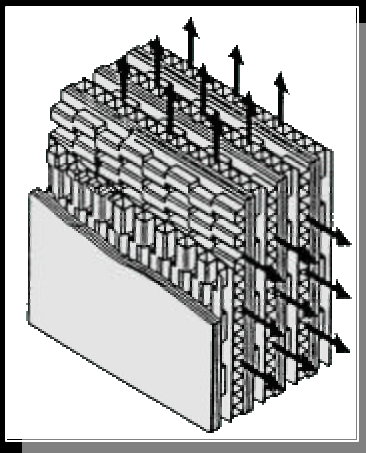
System Features

- System features
 - High efficiency
 - Low cost
 - Low emissions and low noise
- Planar SOFC technology for hybrid power generation
 - High power density
 - Reduced cost

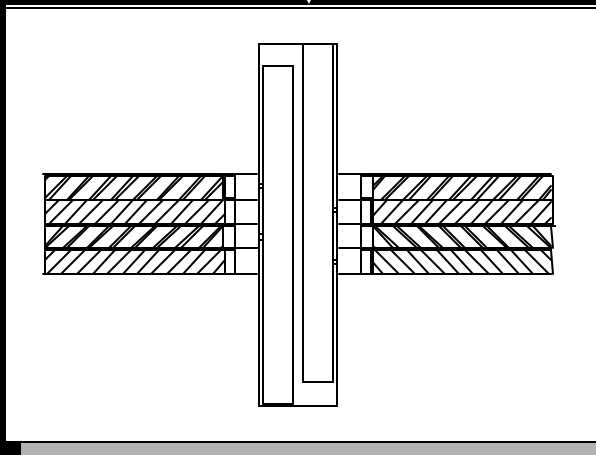


SOFC Stack Configurations

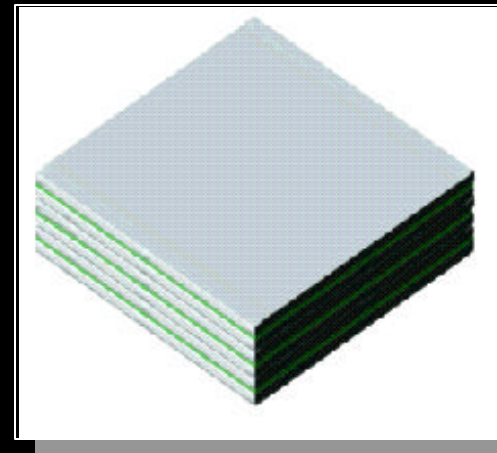
- Thin film electrolytes
- Thin foil metallic interconnects
- Gas manifold options
- Gas flow configuration flexibility



Crossflow Design



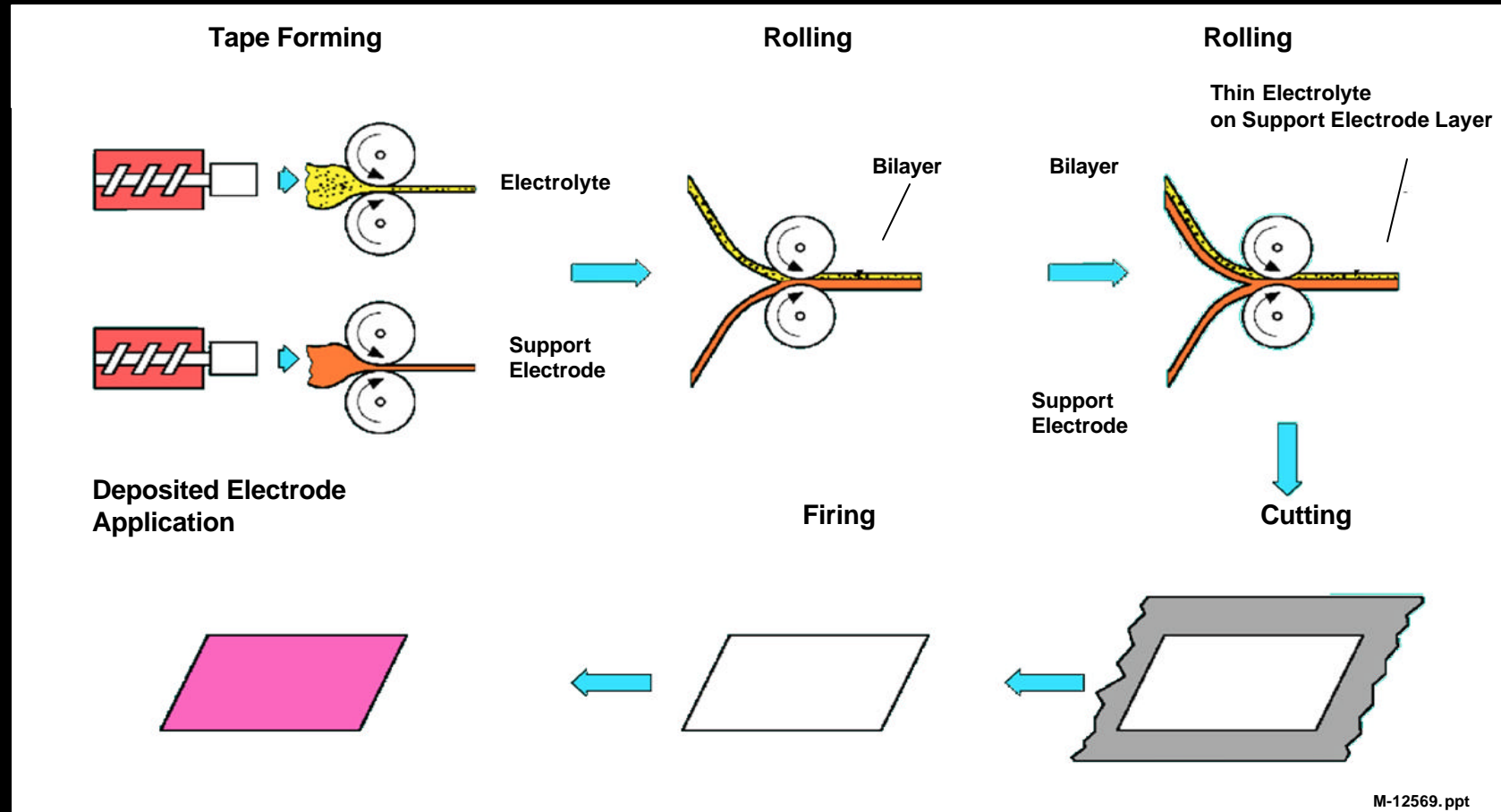
Radial Flow Design



Unitized Cell Design

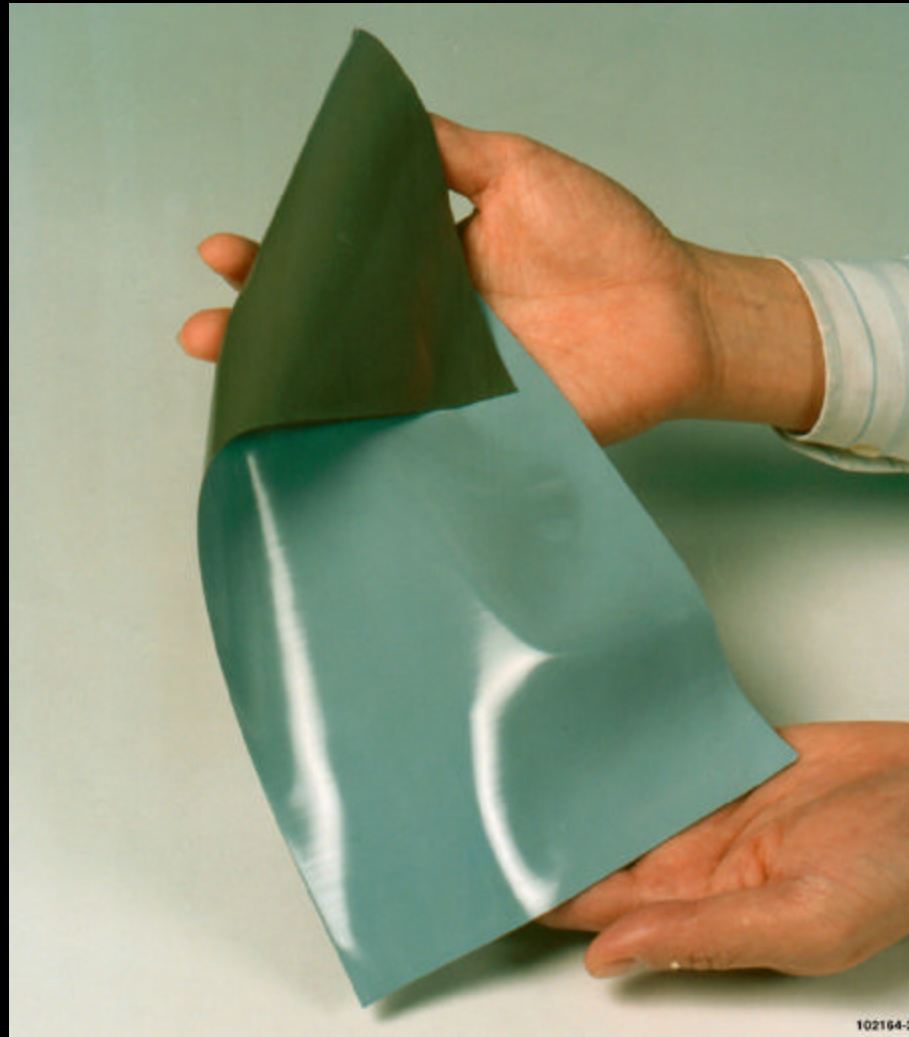


Cell Fabrication



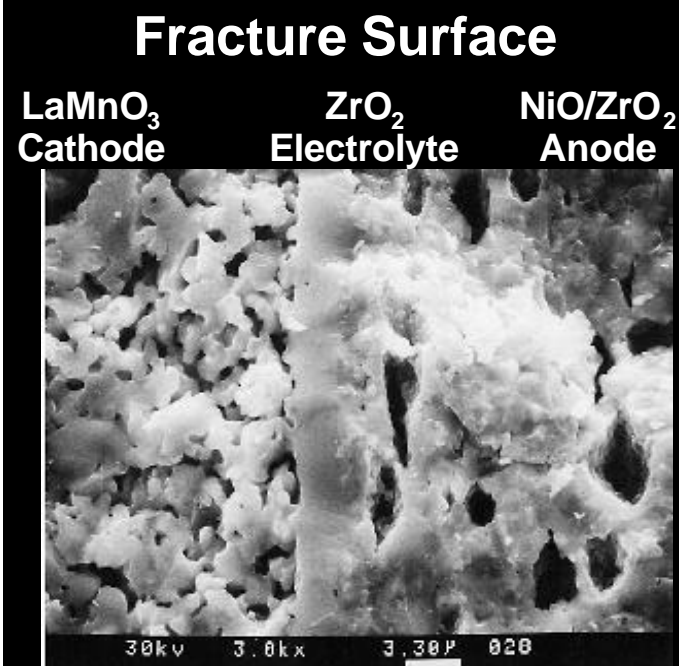


Green Thin Electrolyte/Anode Bilayer Tape





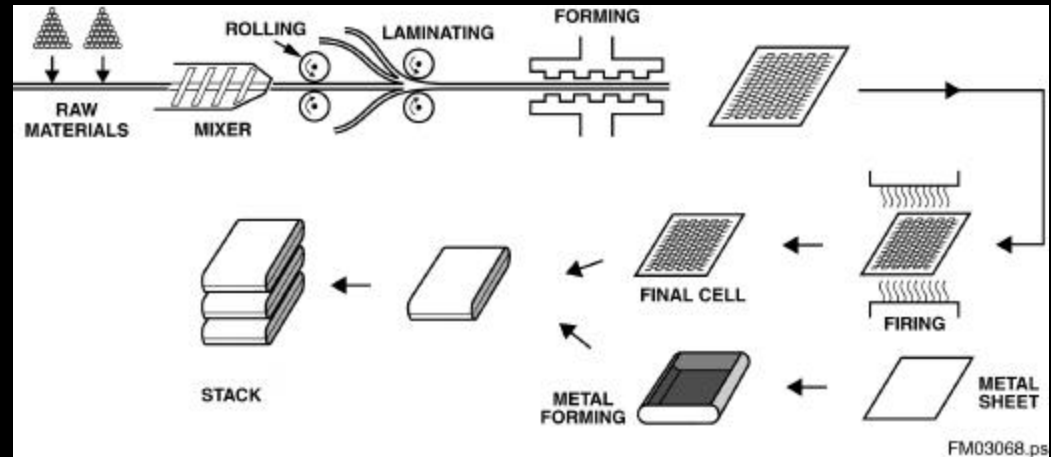
High-Performance Anode-Supported SOFC



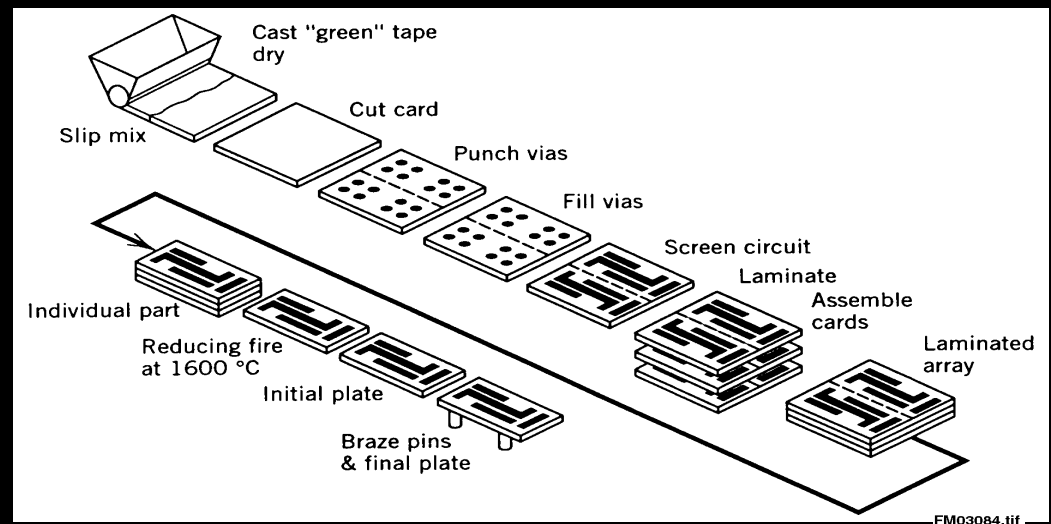


Low Cost Manufacturing Process

- Fabrication process with tape calendering

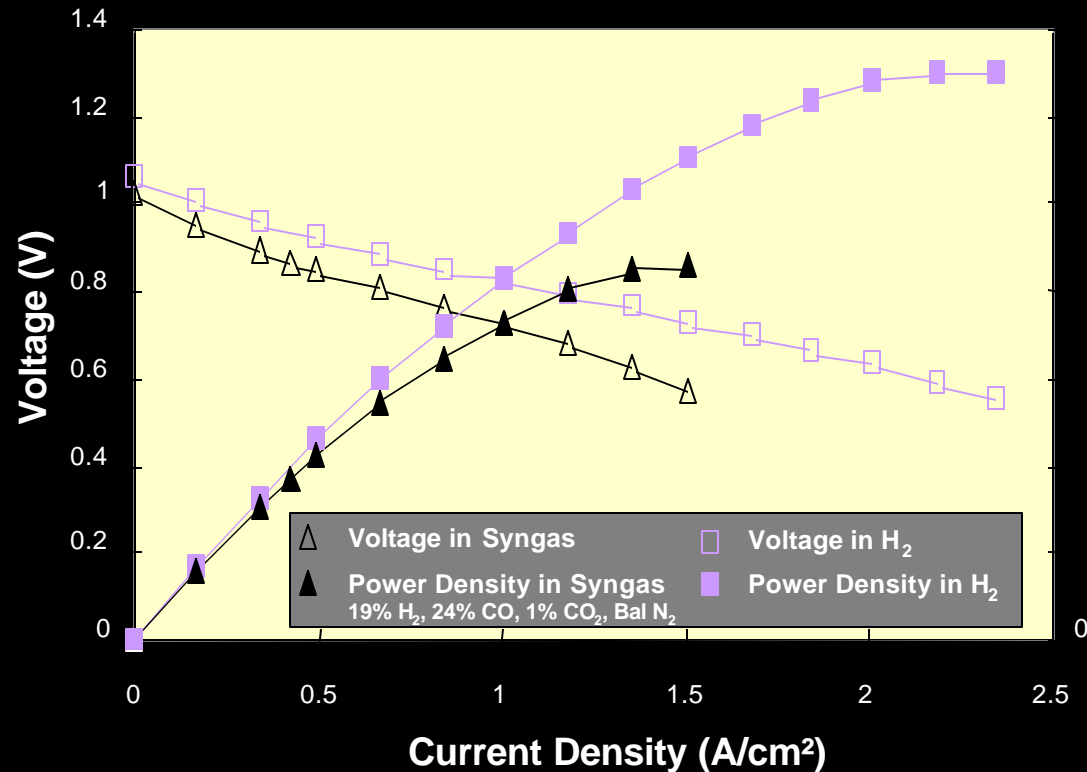


- Multilayer electronics fabrication process





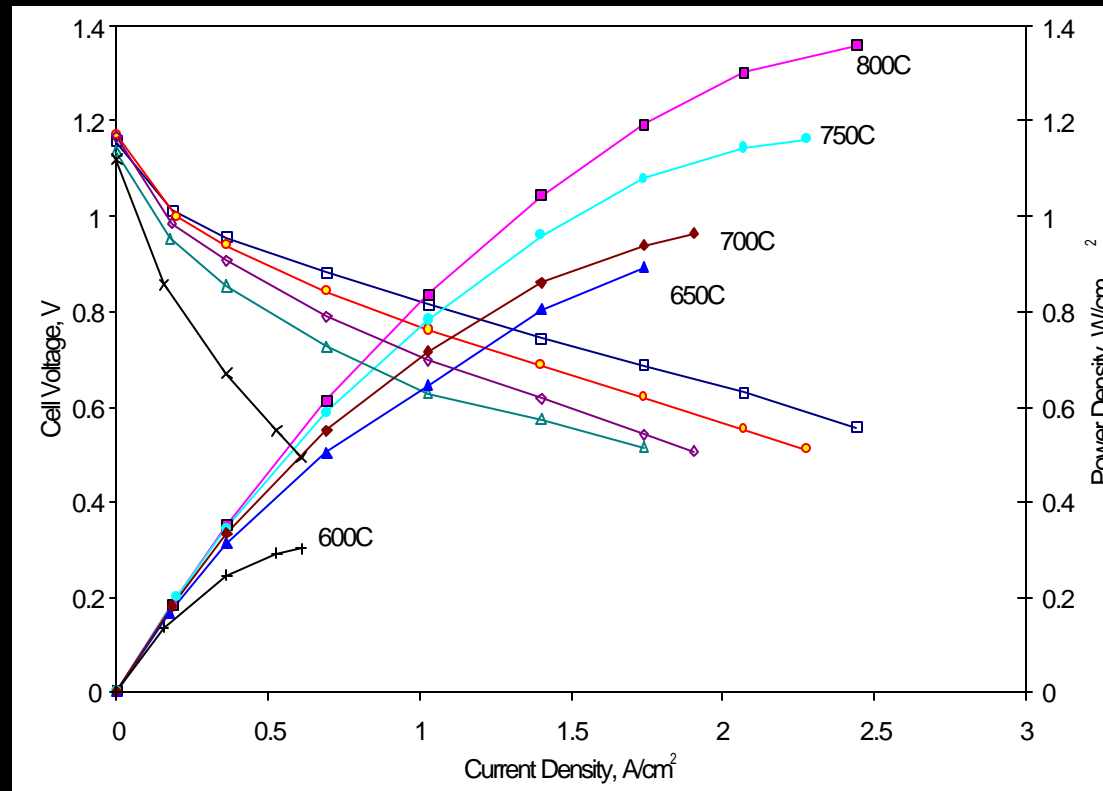
SOFC Cell Performance



- 800°C operation
- Peak power density:
 - 1.3 W/cm² in hydrogen
 - 0.85 W/cm² in syngas



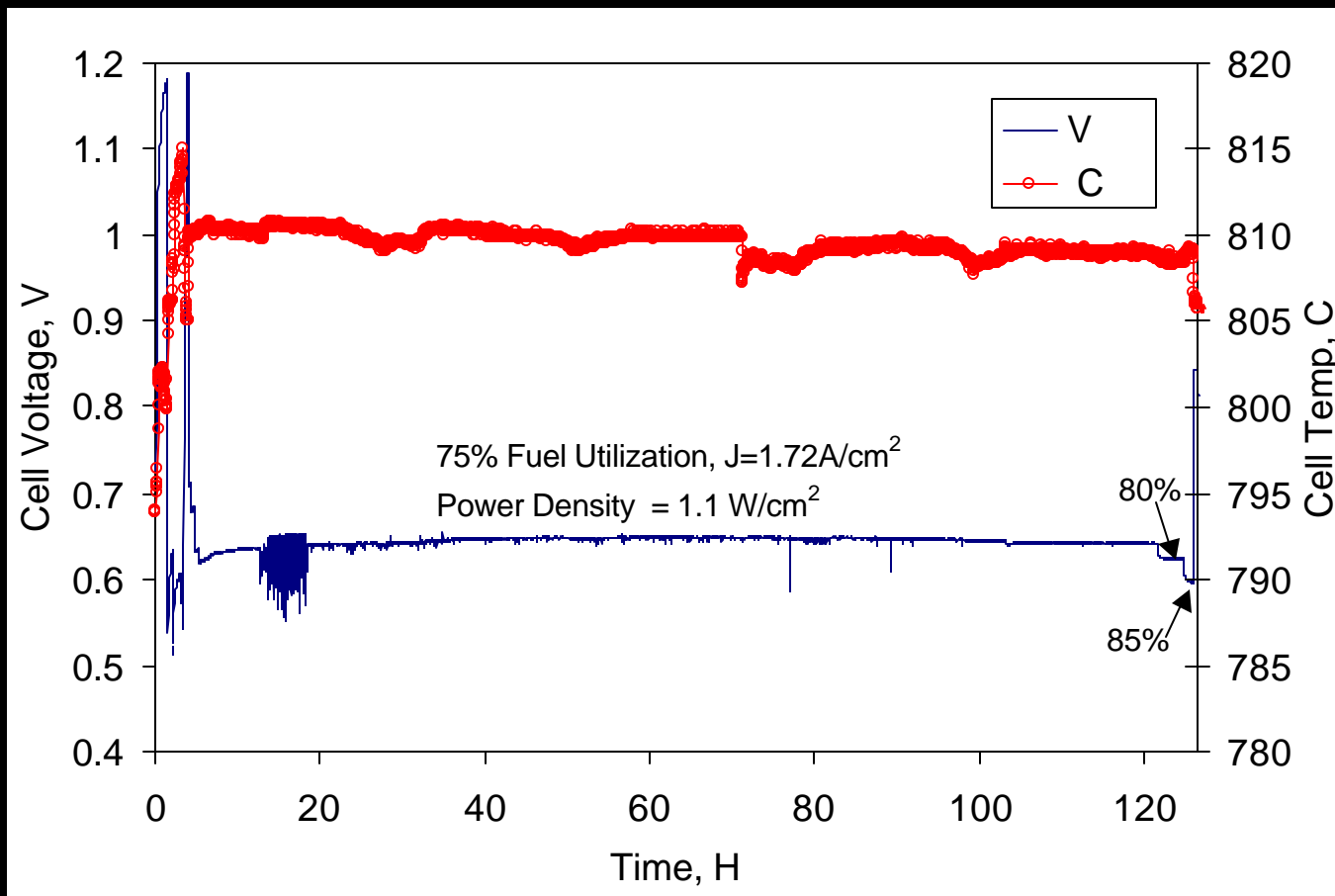
SOFC Cell Performance at Reduced Temperatures



- High power densities (e.g., 0.9 W/cm² at 650°C) achieved at reduced temperatures (<800°C) with anode-supported thin-electrolyte cells

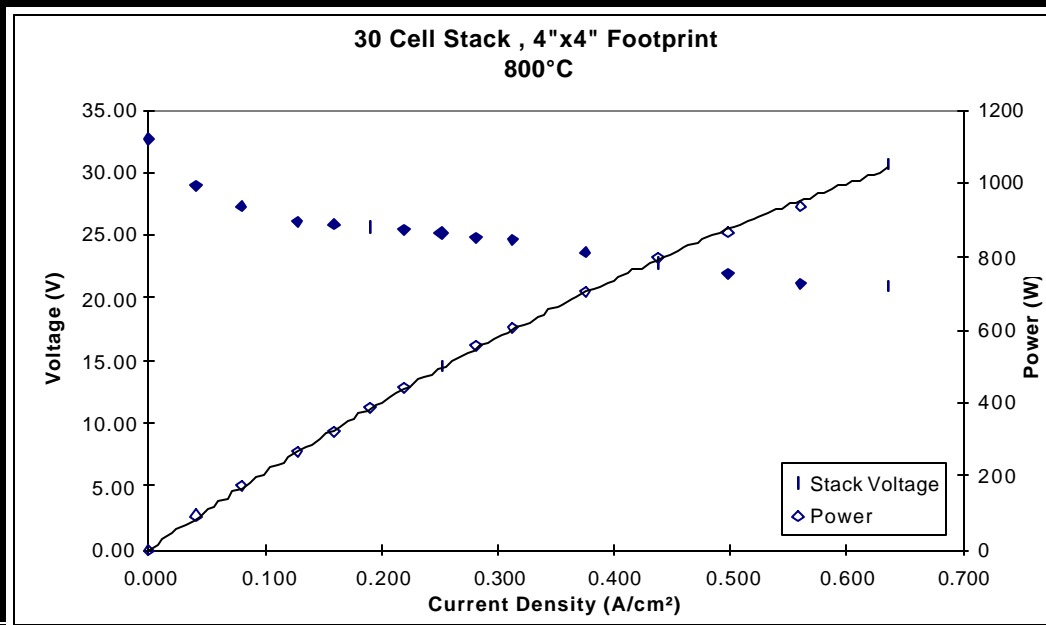


Cell Fuel Utilization





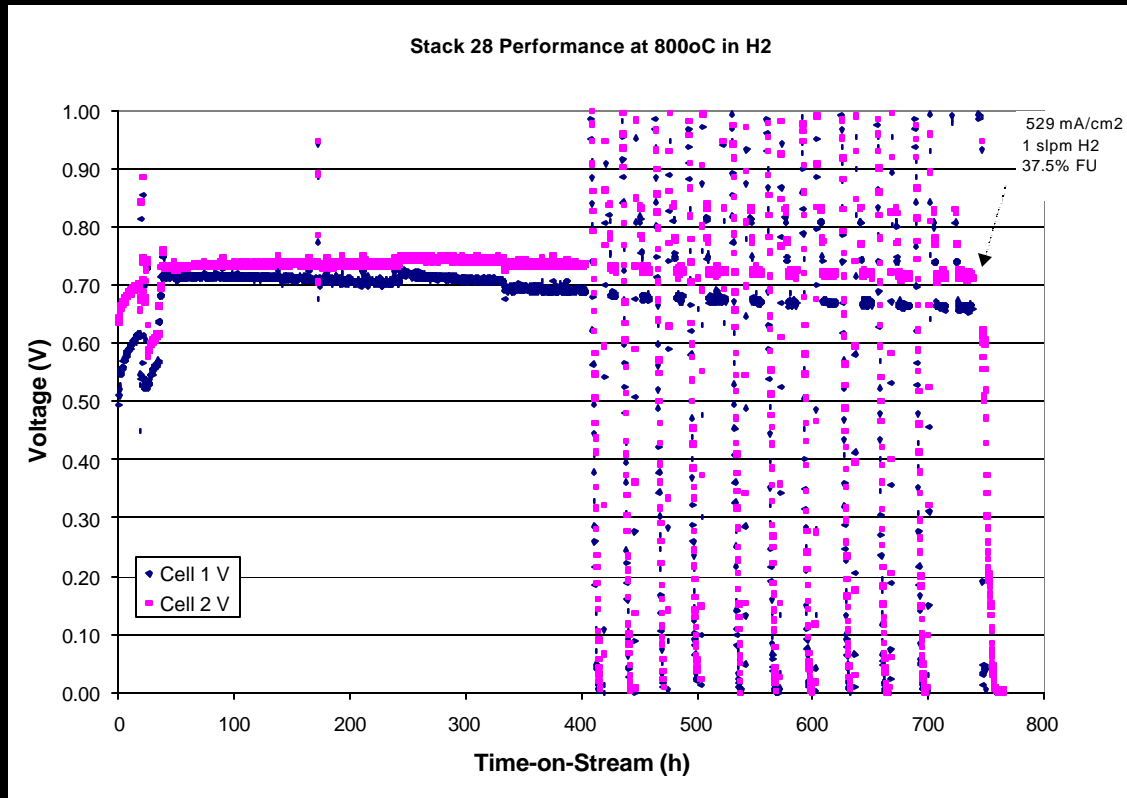
SOFC Stack Performance



- 10 cm x 10 cm footprint
- 800°C operation in hydrogen and air at ambient pressure
- Power:
 - 1.1 kW at 0.7 V / cell
 - 1.4 kW at peak power
- Power density:
 - 0.42 W/cm² at 0.7 V/cell
 - 0.6 W / cm² at peak power
 - 0.7 kW / kg, 0.7 kW / L at peak power
 - 0.53 kW / kg, 0.53 kW / L at 0.7 V/cell



Stack Thermal Cycling



- Multiple thermal cycles without significant performance degradation
- Minimal change in open circuit voltage and voltage under load between cycles

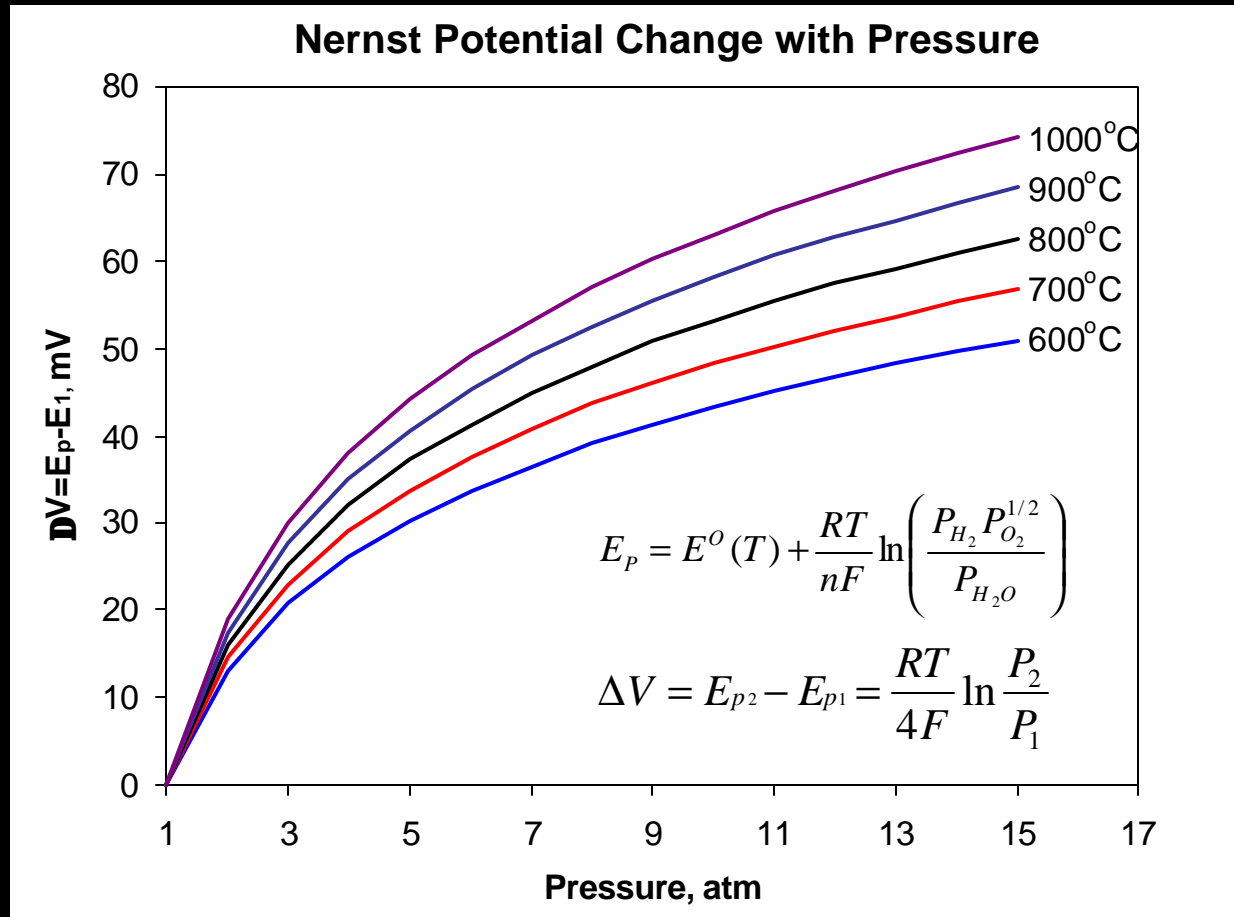


SOFC Performance Enhancement with Pressure

- Cell performance is enhanced with pressurized operation thermodynamically and kinetically
 - Increase in Nernst potential
 - Decrease in activation polarization
 - Exchange current density
 - Decrease in concentration polarization
 - Limiting current density



Nernst Potential Increases with Pressure



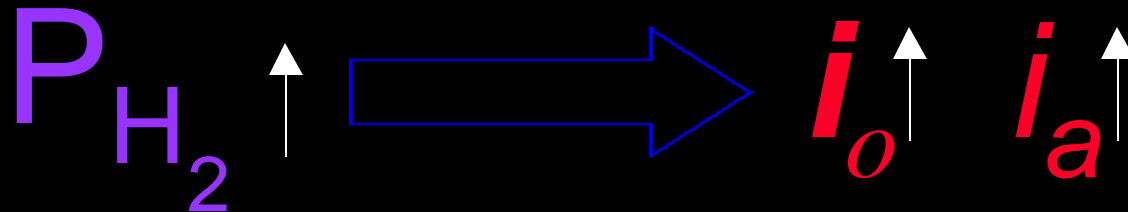


Electrode Kinetics Enhanced with Pressure

Pressure will benefit electrode kinetics through increase in both exchange current density and limiting current density

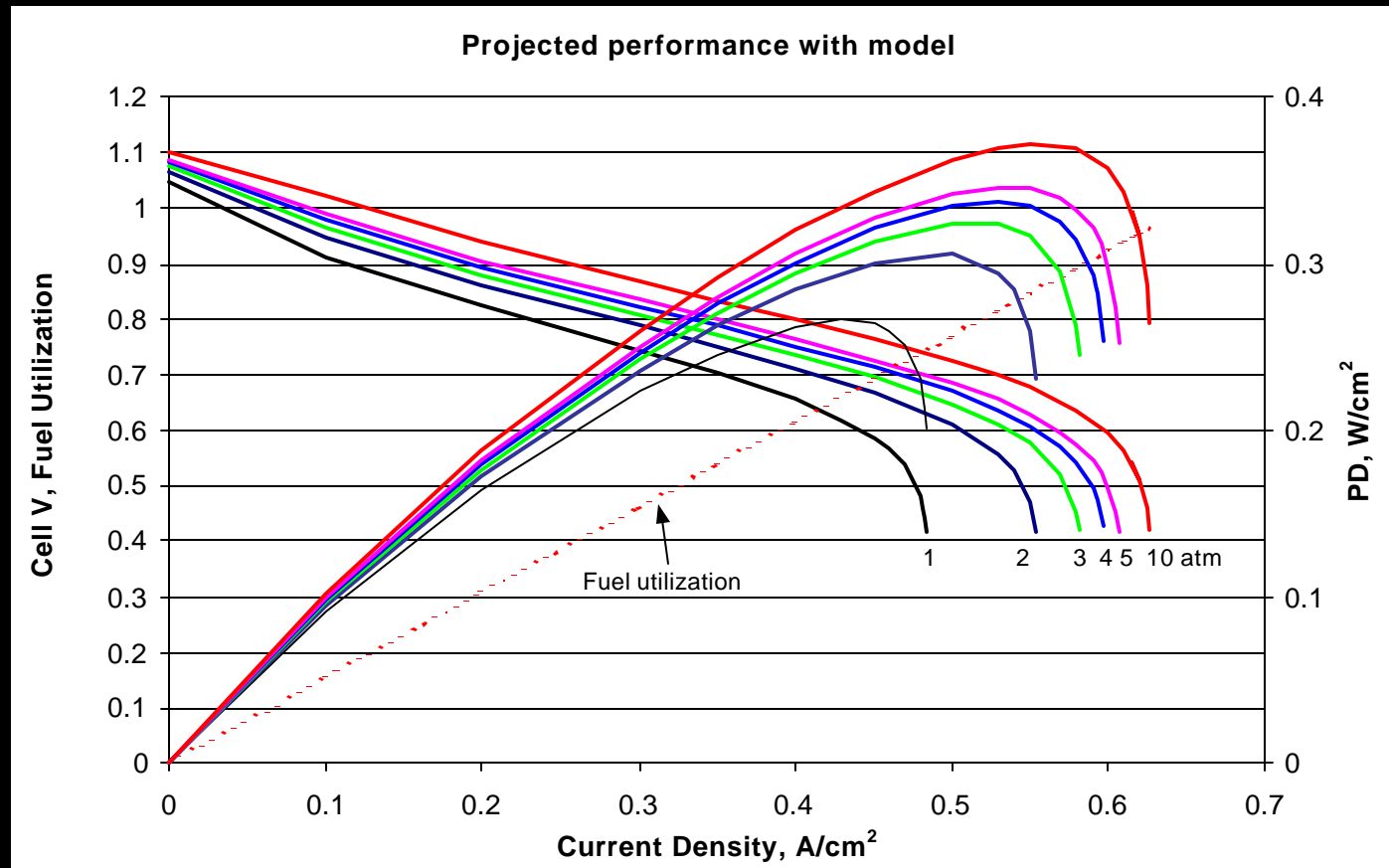
Exchange Current Density i_o

Electrode Limiting Current Density i_a





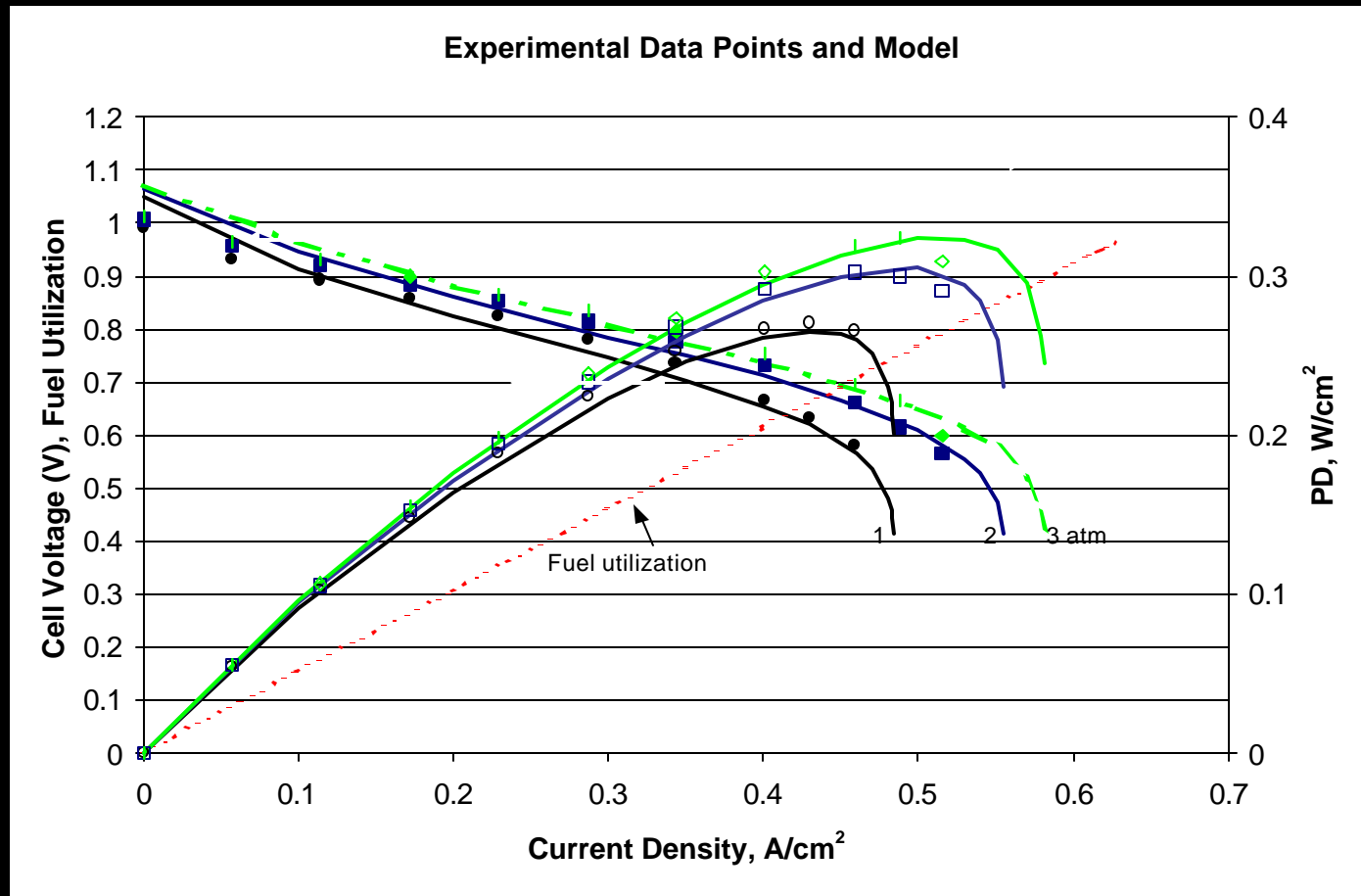
SOFC Performance Projection



- Significant performance enhancement observed from 1 to 3 atm
- Moderate performance improvement expected from 4 to 10 atm



Pressurized SOFC Performance





Concluding Remarks

- Planar SOFC technology for hybrid power generation over a broad range of system sizes
- Planar SOFCs based on thin-electrolyte anode supported cells
 - Simple, low-cost tape calendering fabrication process
 - High power density
 - Pressurized operation

